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Coordinates of the Borowiec SLR station in 2015-2018

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Objectives

Verification of the quantity and quality of observations of a laser station in Borowiec after a five-year break in observations

Comparison of station coordinates with the results obtained in 2006-2009

Abstract

The satellite laser ranging station at Borowiec (7811) in March 2010 interrupted the current continuous activity (1988-2010) due to laser wear and the inability to repair it. In 2014, funds were finally obtained from the Ministry of Science and Higher Education for the purchase of a new laser. After the modernization of the system and measurement tests, the first good observation of the LAGEOS satellite was obtained on 10 July 2015. From then until May 2018, 375 passes of LAGEOS satellites were observed. After such a long break in the station activity (five years) it is necessary to check the quality of the observations made by orbital analysis of the results. The analysis was carried out using the GSFC NASA GEODYN-II orbital program. Taking into account the criterion of minimum 50 normal points for one monthly orbital arc, 23 coordinates of the laser station at Borowiec were computed for the period from August 2015 to May 2018. The station position stability and standard deviation of the determination of coordinates were determined. These results confirm the high accuracy of the designated coordinates of the station at the level of 10 mm with a precision of 3 mm.

Input data

Results of SLR stations - 15 stations
Atmospheric parameters at the station level: pressure, temperature, humidity
The correction for the mass center of the satellite: 25.1 cm
Cross section and mass of the satellite: 0.2827 m2, 406.965 kg (L1), 405.380 kg (L2)
Laser wavelength: 532 nm
Tropospheric correction: Mendes-Pavlis model

Output data

Satellite state vector: 6 parameters
Geocentric Borowiec station coordinates : 3 parameters
Empirical acceleration: 9 parameters at 5 days intervals

Numerical Integration

Cowell's method
Orbit integration step size: 120 sec
Arc length: 1 month

GSFC NASA orbital program GEODYN-II

models of forces and parameters LAGEOS satellites

Model of the Earth's gravity field: EGM2008, 20x20
Earth tide model: IERS Conventions 2003
Ocean tide model: GOT99.2
The tidal parameters of the earth's crust:
k2 = 03, k3 = 0.093, phase k2 = 0.0
Gravity field of the Moon, Sun and planets: DE403
Solar radiation pressure: CR = 1.13
Earth albedo
Earth relativistic effects
Yarkowski thermal drag
Precession and nutation: IAU2000
Position and velocity of the stations: ITRF2014
Pole motion and UT1: IERS C04 (every 1 day)
Love and Shida numbers: H2 = 0.6078, L2 = 0.0847
Tide pole

List of base SLR stations for orbits determination

08.2015 - 04.2018

Station No	Station	Number of monthly arcs	Number of NP	Sigma [mm]	Coordinates stability [mm]
7090	Yarragadee (Australia)	33/33	67833	1.0	5.6
7105	Greenbelt (Maryland-USA)	33/33	25313	1.5	6.1
7110	Monument Peak (California-USA)	33/33	13675	2.0	7.2
7119	Haleakala (Hawaii-USA)	33/33	12045	2.2	11.4
7124	Tahiti (Franch Polinesia)	33/24	3870	3.3	11.6
7501	Hartebeesthoek (South Africa)	29/24	10211	2.1	10.3
7810	Zimmerwald (Switzerland)	27/27	26500	1.4	6.1
7825	Mount Stromlo (Australia)	33/33	25526	1.5	4.8
7838	Simosato (Japan)	29/29	16769	1.7	6.8
7839	Graz (Austria)	33/33	10721	2.1	5.7
7840	Herstmonceux (UK)	33/33	21350	1.5	4.3
7841	Potsdam (Germany)	32/31	11318	2.2	5.9
7845	Grasse (France)	33/33	10019	2.2	7.3
7941	Matera (Italy)	33/32	28544	1.6	7.4
8834	Wettzell (Germany)	33/31	7642	2.9	6.7
7811	Borowiec (Poland)	30/22	3246	4.8	10.4

Changes in the Borowiec SLR system in 2014

Last observation before the laser failure: 24/03/2010, Ajisai

- a new laser for satellites: EKSPLA PL-2250, 50 mJ, 60 ps, 10 Hz
- a new laser for space debris: Continuum Surelite III, 450 mJ, 3-5 ns, 10 Hz
- replacement of optics: main mirror 65 cm, secondary mirror 20 cm, dielectric mirrors of the Coude path
- fast start photodiode

First observation after the break: 2/03/2015, Jason-2
First observation of the LAGEOS satellite: 10/07/2015

Summary of the orbital analysis - 1

Borowiec SLR station - 7811

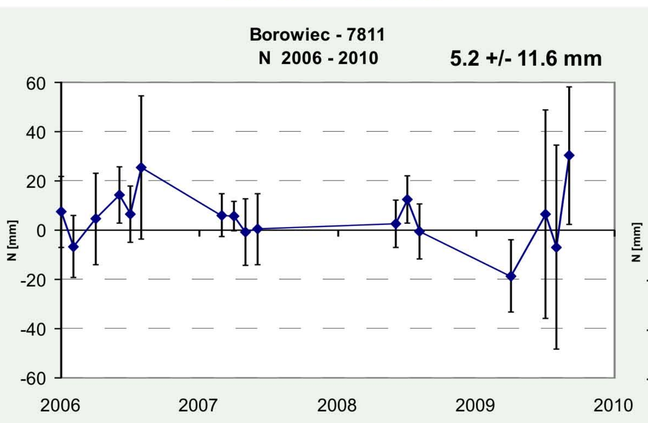
	2006 - 2010	2015 - 2018
observation time	3.7 years	2.7 years
number of monthly arcs	17	22
number of NP - LAGEOS-1	1666 151/arc	1932 102/arc
number of NP - LAGEOS-2	959 74/arc	1314 66/arc
Range Bias - LAGEOS-1	11.7 mm	-7.0 mm
Range Bias - LAGEOS-2	15.7 mm	-7.9 mm
RMS - LAGEOS-1	22.8 mm	18.6 mm
RMS - LAGEOS-2	28.2 mm	17.4 mm
number of all orbital points	216654 12744/arc	203160 9235/arc
orbital RMS	17.4 mm	17.2 mm

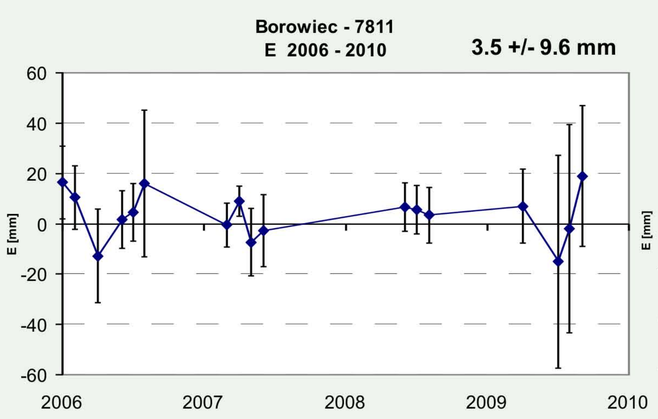
Summary of the orbital analysis - 2

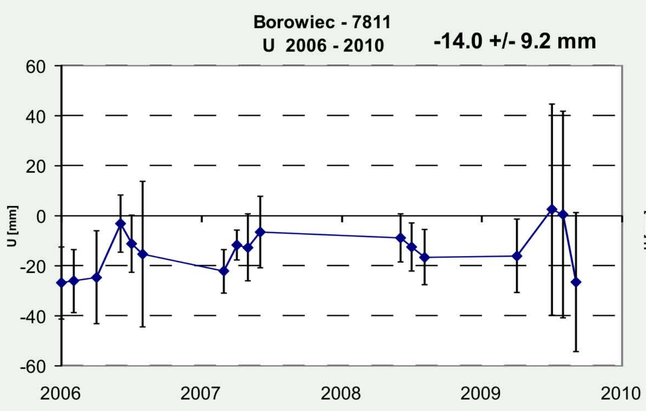
Borowiec SLR station - 7811

	2006 - 2010	2015 - 2018
mean N	5.2 mm	-5.9 mm
RMS N	11.6 mm	10.7 mm
mean E	3.5 mm	3.1 mm
RMS E	9.6 mm	10.6 mm
mean U	-14.0 mm	12.6 mm
RMS U	9.2 mm	10.0 mm
RMS 3D	10.2 mm	10.4 mm
sigma 3D	5.8 mm	4.8 mm
station velocity	23.8 mm/y	26.5 mm/y
horizontal velocity	23.8 mm/y	26.5 mm/y
vertical velocity	2.3 mm/y	0.2 mm/y
station azimuth	54.2°	39.6°

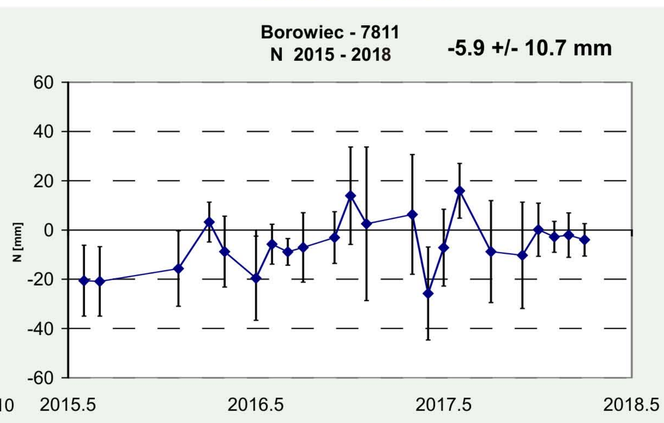
2006 - 2010

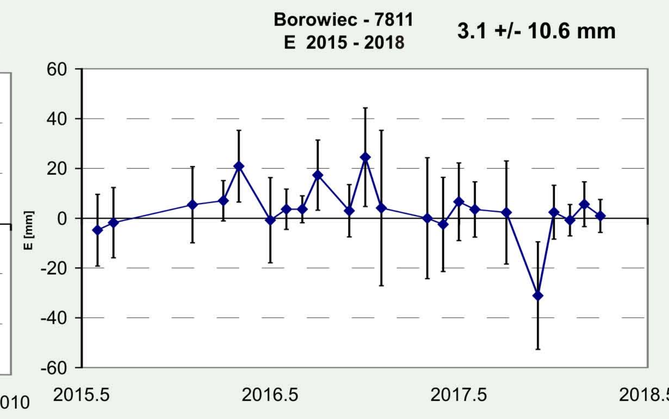


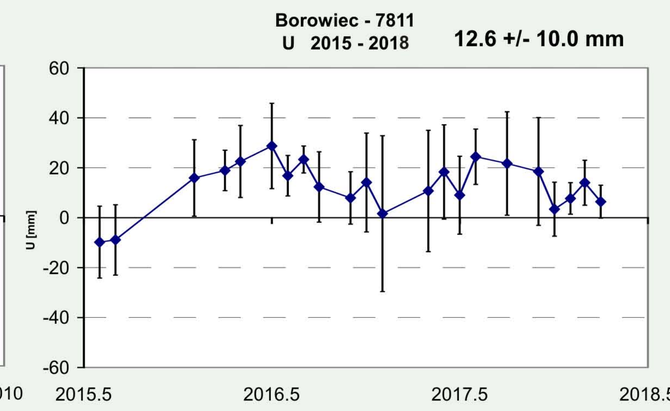


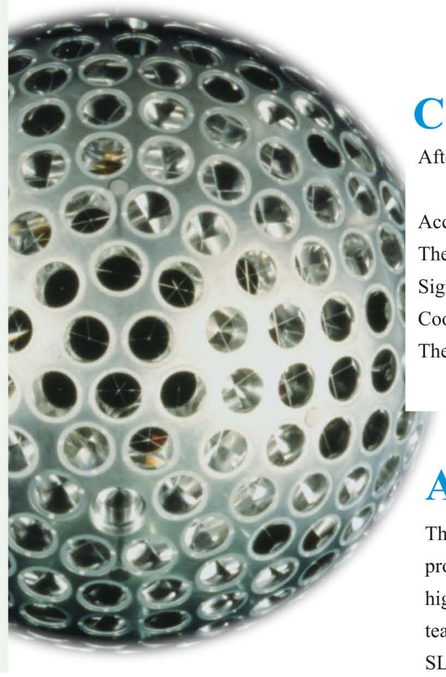


2015 - 2018









CONCLUSIONS

After the 5-year break, the results obtained in the years 2015-2018 do not differ significantly from the results from the period 2006-2010
Accuracy and precision of observation is 10 mm and 5 mm respectively for both periods
The number of measuring points per pass increased significantly
Significant differences in the Range Bias of about 2 cm were detected
Coordinates RMS stability is at the level of 12 best SLR stations
The number of observations is insufficient, but it requires the replacement of a laser telescope to perform observations 24 hours / day

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